UNITED STATES SENATE

Committee on Governmental Affairs

Subcommittee on
Energy, Nuclear Proliferation, and
Government Processes

Testimony by

Lester Machta, Director
Air Resources Laboratory
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

June 30, 1986

Miami, Florida

Thank you, Mr. Chairman

Radioactivity released to the atmosphere from nature, nuclear facilities, or a nuclear detonation is carried by air currents and becomes deposited by the vagaries of the weather. We know of no means by which the radioactivity might be artificially removed from the air.

Airborne radioactivity can best be tracked with sampling instruments aboard airplanes; a process that allows a large degree of mobility in the search for the radiation. When aircraft sampling is not possible, as was the case within the Soviet Union during the recent Chernobyl accident, it is possible to estimate with some reliability the location and movement of the air which contains the radioactivity from meteorological observations.

Most of mankind's previous experience regarding the long distance transport of radioactivity was derived from the era of atmospheric nuclear testing in the 1950's and early 1960's and a few subsequent nuclear tests. However, the release of radioactivity to the air from a nuclear power station accident differs in at least one way from that produced by nuclear tests. The radioactivity is injected near the ground and not at high altitudes as with tests. The two scavenging mechanisms that physically remove the radioactivity from the air, namely, wet and dry fallout, are more effective when a radioactive cloud is near the ground rather than at high altitudes.

My organization, the National Oceanic and Atmospheric Administration (NOAA), does not monitor radioactivity in air. With its meteorological expertise, it can provide forecasts on the movement of air containing radioactivity and where rain is likely to deposit the radioactivity. The Department of Energy, through its Lawrence Livermore National Laboratory, provides a similar service, especially for releases from facilities within the United States. NOAA, however, is responsible for tracking other forms of environmental pollution such as volcanic dust, radioactivity from foreign atmospheric nuclear tests, and smoke from forest fires. In doing so, it receives assistance from other agencies and promptly reports its findings to them. We use computer terminals linked by telephone to the National Weather Service, National Meteorological Center, near Washington, D.C. in order to obtain up-to-date meteorological data. Our 30 or more years of experience and research using atmospheric pollutants and tracers permits expert on-the-spot judgements of various factors like cloud rise, movement over irregular terrain, and rain effects that must be taken into account.

NOAA Climatology Capabilities

#1 I am now going to address the air flow from Cienfuegos, Cuba to various locations in the Gulf of Mexico, the Caribbean, Central America, and particularly, the southeastern United States.

Exhibit 1 shows a map with air trajectories that originate from a power plant that is proposed for Cienfuegos. These trajectories trace the flow for the centerline of the air, or air containing radioactivity if any were released. The altitudes chosen for the calculations, near sea level (solid line) and 5000 ft (dashed line), were selected because, in our estimation, they are the most relevant to a radioactive release from a nuclear power plant and because they are standard levels in the atmosphere where weather analyses are available. Both trajectories start on January 1, 1985 and the numbers along each trajectory indicate daily (24 hour) positions after start. Note that the paths differ. Had we run trajectories at levels between the two shown on the Exhibit, they would likely lie somewhere in between. In addition to transport along a trajectory path, a mass of air would spread horizontally with time so that after two days of travel, it might have a radius of about 100 miles or so around the two-day point on the centerline shown on the Exhibit.

#2 Trajectories calculated in a similar manner are used for Exhibit 2 which shows the probability of any point in the Gulf, the Caribbean, Central America, and the southeastern United States being overridden by air which initially started from Cienfuegos. This picture presents the annual average probability derived from all weather patterns in 1984--the picture for 1985 (Exhibit 9 in the Appendix) was not much different. One could interpret Exhibit 2 as follows: if radioactivity were constantly emitted from Cienfuegos, the numbers would reflect the percentage of the time air containing radioactivity would pass over an area, or viewed in another way, the percentage of the time a monitoring station in that area would detect the radioactivity in air, or if it rained, in rainwater. For example, radioactivity could be expected over southern Florida about 25% of the time.

The probability of air from Cienfuegos passing over an area as shown in Exhibit 2 applies to an entire year. More detailed information on probabilities can be obtained by considering periods shorter than one year. We have chosen a 3-month interval as the shortest representative period for air flow statistics based on the twice-daily trajectories. #3 For example, during the period January through March 1984, the likelihood of southern Florida being affected by air orginating from Cienfuegos is about 45% as shown in Exhibit 3, which is much greater than the annual value of 25%. The other 3-month probabilities for 1984 and 1985 appear in the Appendix. It should be emphasized that, unlike the year-to-year similarities of the annual percentages, seasonal probabilities can differ significantly reflecting seasonal changes. In addition, any one season can differ from year to year because of geographic shifts in large scale weather patterns. As an example, the probability of southern Florida being affected by air from Cienfuegos was about 45% during January-March 1984 but only about 25% during the next 3-month period of April to June 1984 (see Appendix, Exhibit 6). The 3-month differences from one year to the next can be illustrated by considering the 45% probability in southern Florida for January-March 1984 as compared to about 30% for the same 3-month period in 1985 (see Appendix, Exhibit 10). When applying any of the above probablities we emphasize that, for any single nuclear accident, the radioactivity would take one specific path based on the air flow at that time and would, therefore, either "hit" or "miss" southern Florida.

#4 Exhibit 4 shows the average time it takes air from Cienfuegos to reach an area on the map. Thus, on those times when the air moves to southern Florida, it will take, on the average, about 2 to 3 days. #5 Exhibit 5 shows the shortest travel time to an area from Cienfuegos. For southern Florida, the shortest time is less than 1 day rather than the average time of 2 to 3 days. An earlier arrival, with less horizontal spread, allows greater dry deposition or wet deposition if rain is encountered, and less radioactive decay.

In this statement, Mr. Chairman, there have been no estimates of amounts of radioactivity or hazard to people or the environment. These estimates lie outside NOAA's area of expertise. NOAA will advise when and where radioactivity injected into the atmosphere might reach sensitive areas so that appropriate monitoring or other steps can be taken.

Appendix to Testimony of Dr. Lester Machta, NOAA, 30 June 1986

Miami, FL

This appendix amplifies and explains some of the statements and Exhibits in the body of the testimony.

1. Preparation of trajectories of air originating at Cienfuegos.

It is difficult to predict in advance the atmospheric layer that transports radioactivity following a nuclear reactor accident. The best judgement of NOAA scientists calls for transport mainly in layers at or below 5000 ft. altitude. Therefore, the path of air from Cienfuegos, Cuba has been calculated at an altitude near sea level and at 5000 ft. starting at 00 GMT (Greenwich Mean Time) and 12 GMT every day in 1984 and 1985. Meteorological analysis needed as input to NOAA trajectory computer programs are readily available at these altitudes and times. The mass of air at each of these altitudes is permitted to spread horizontally as it moves along a trajectory path such that its radius in nautical mile equals two times the travel time expressed in hours (e.g., after 24 hours of travel, the radius would be 48 nautical miles). Each trajectory is computed for 10 days; Exhibit 1 shows only part of the calculated trajectory paths.

2. Climatology of air from Cienfuegos.

Calculations were made of the percent of time air from Cienfuegos overrode a grid 0.2 degrees latitude and 0.2 degrees longitude over the map area shown in Exhibit 2 of the testimony. Trajectories were started twice daily at 2 altitudes for two one-year periods. A single trajectory was counted only once for each grid point. The number of times that the air passed over a grid was then divided by 732 (two trajectories per day for one year) and then multiplied by

100 to express the number in a percentage. Percentages from the two altitudes were combined to produce the Exhibit.

For Exhibit 3 of the testimony, the same procedure was employed but the percentages were obtained by dividing by 182 (two trajectories per day for 91 days between January 1 through March 31, 1984). The same procedure was used to obtain the percentages on Exhibits 6 through 8 and 10 through 13 in this Appendix.

For each instance of air overriding the 0.2 by 0.2 degree grid, the time of arrival in hours was determined for each of the two altitudes and an average was computed. In addition, the first arrival was also noted. Analyses of average and first arrival times appear on Exhibits 4 and 5, respectively.

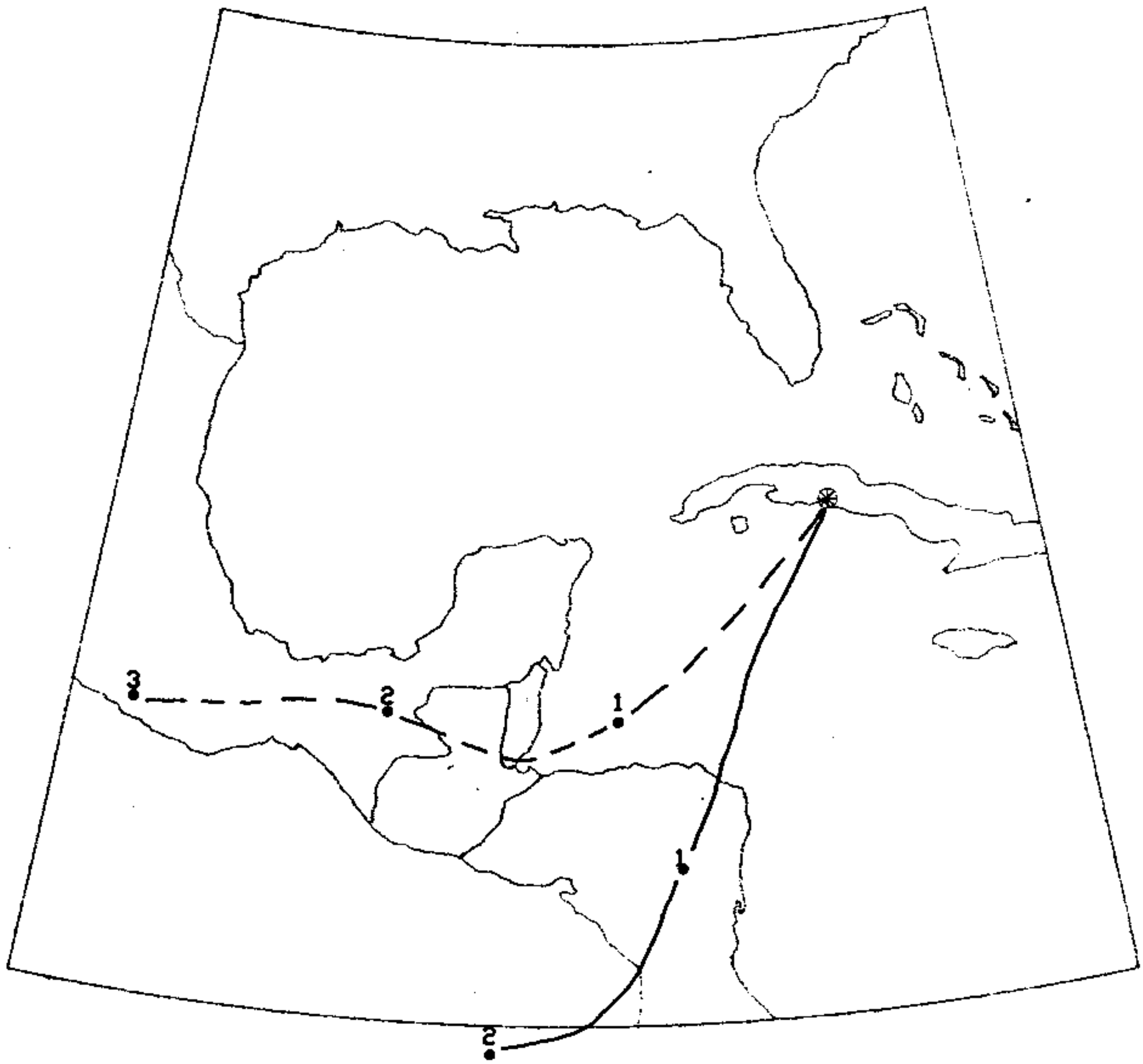

Exhibit 1. Trajectories of air originating at Cienfuegos, Cuba for January 1, 1985 at 00 Greenwich Time for sea level (solid) and 5000 feet (dashed). The numbers indicate positions at daily (24 hour) intervals after start time.

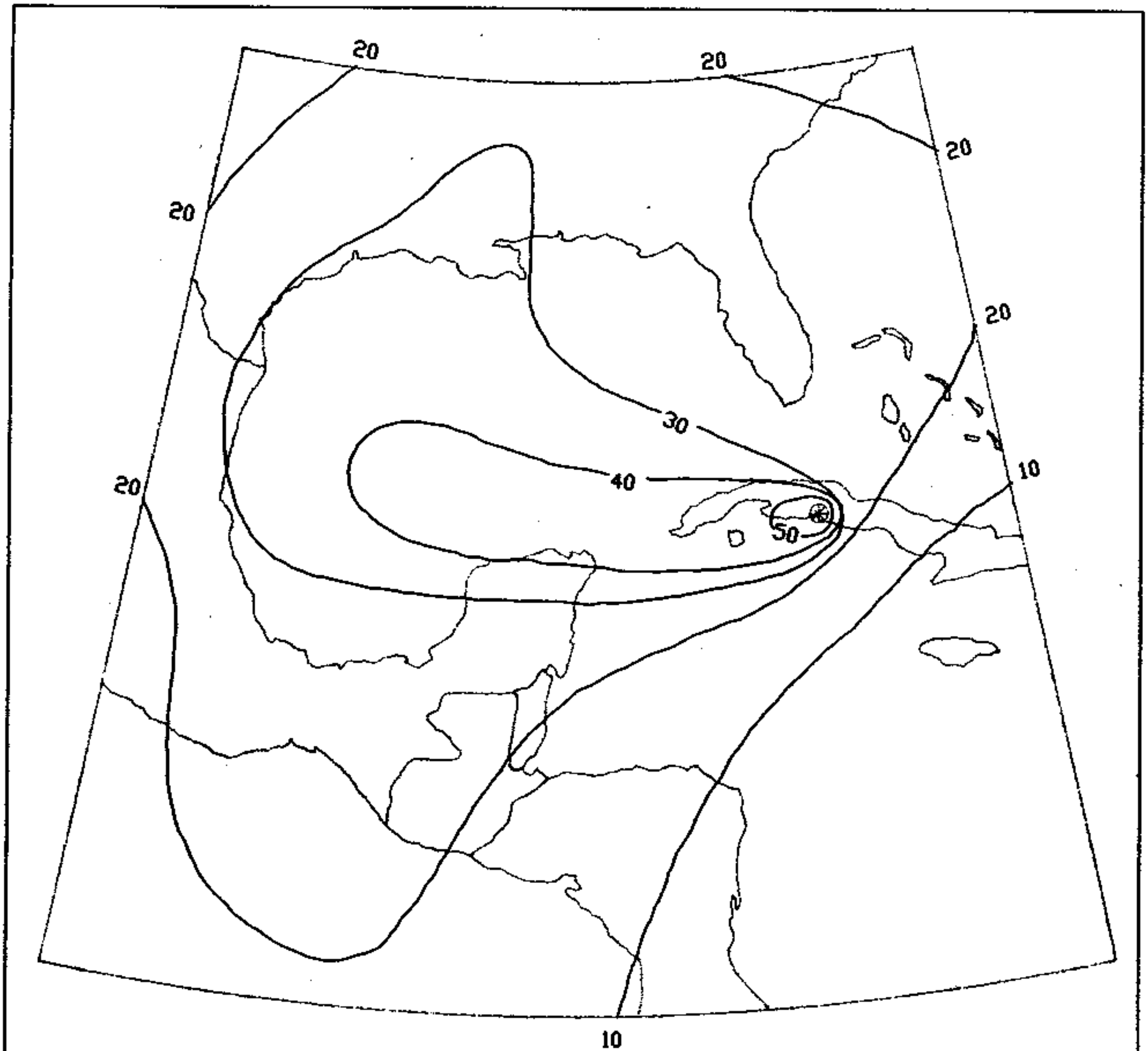

Exhibit 2. **Percentage of time that air originating at Cienfuegos, Cuba would override an area during the course of the year 1984.**

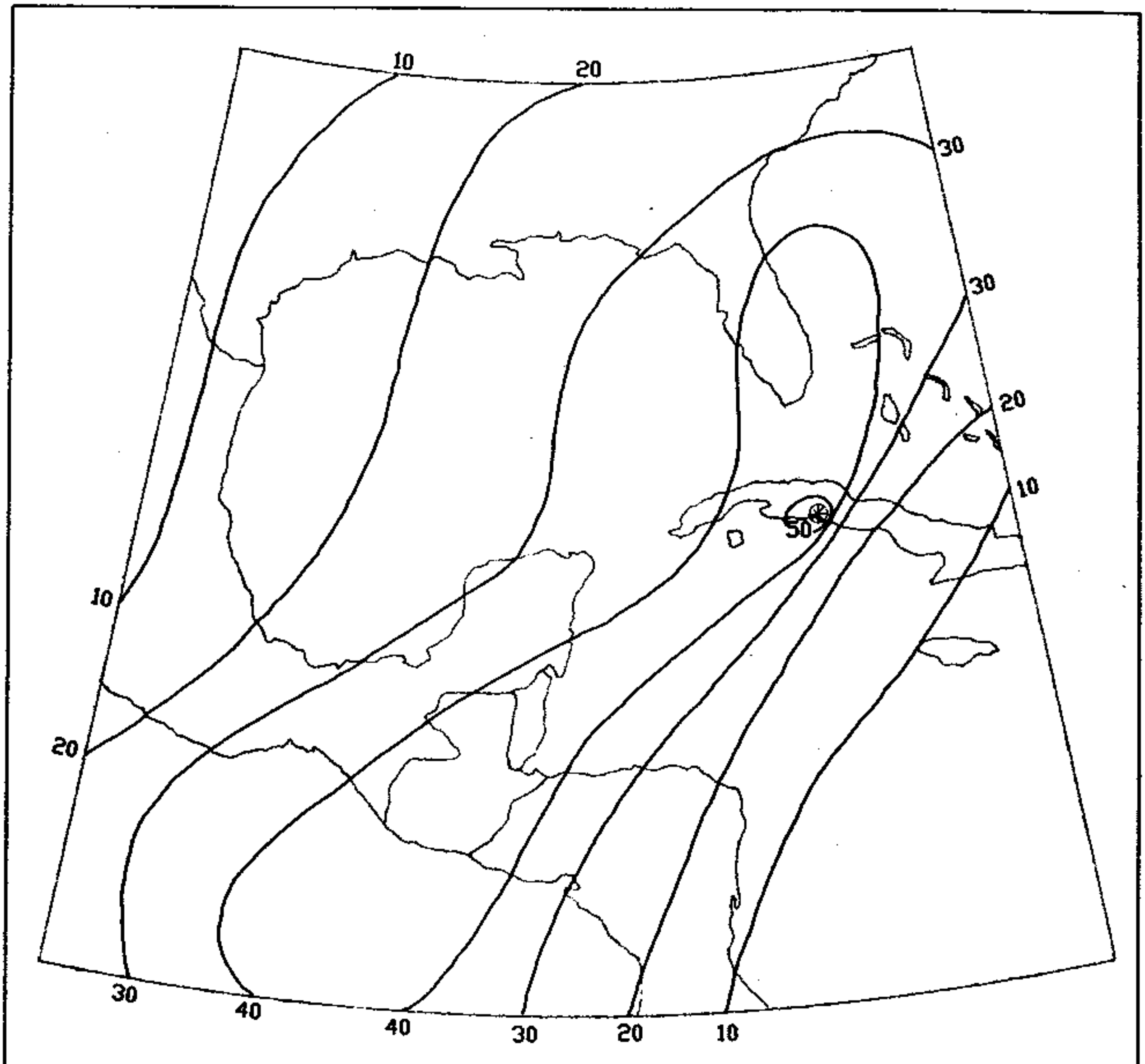

Exhibit 3. Percentage of time that air originating at Cienfuegos, Cuba would override an area during the period January 1 through March 31, 1984.

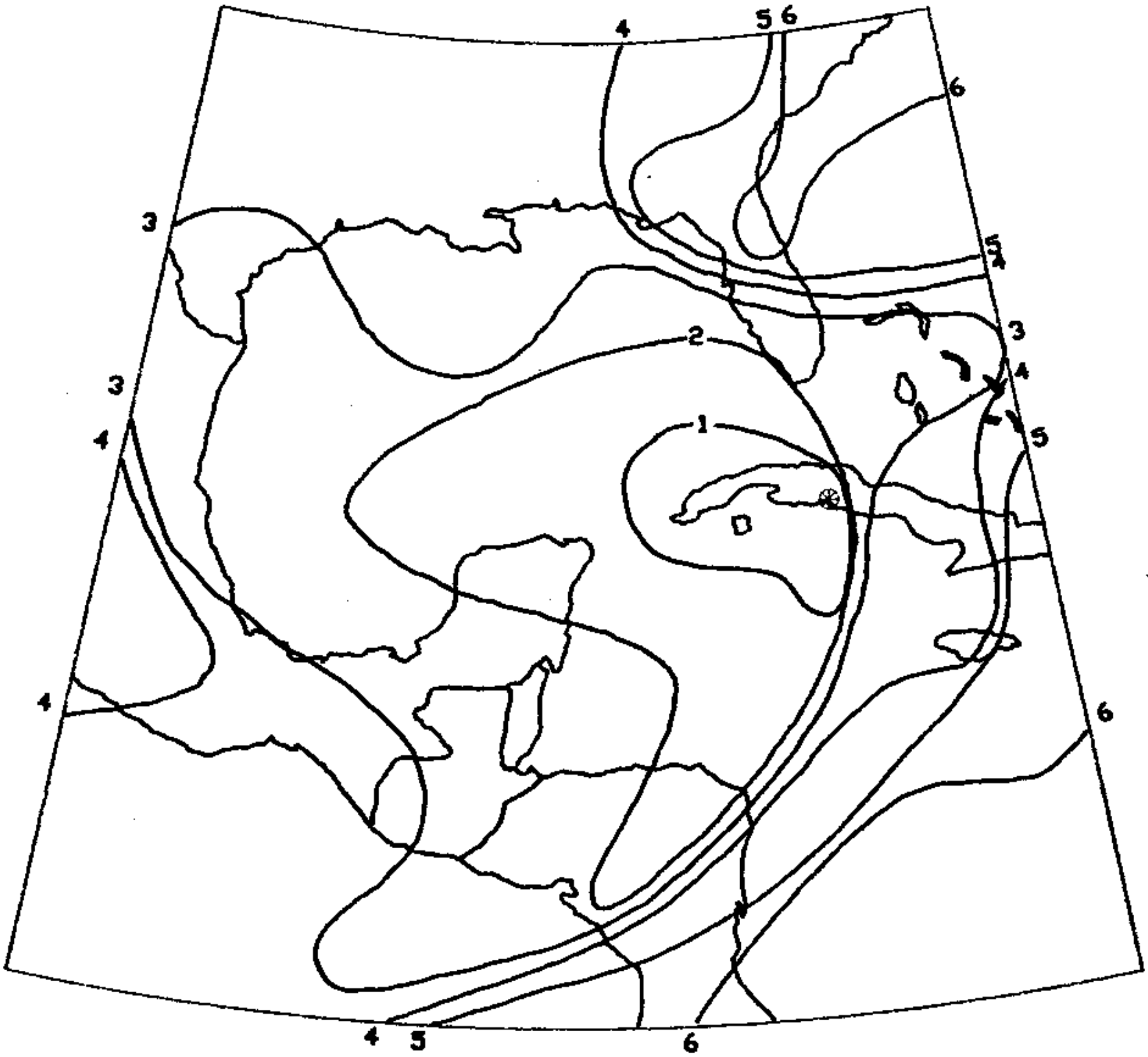

Exhibit 4. Average time, in days, for air to travel from Cienfuegos, Cuba based on a year of trajectory calculations (1984).

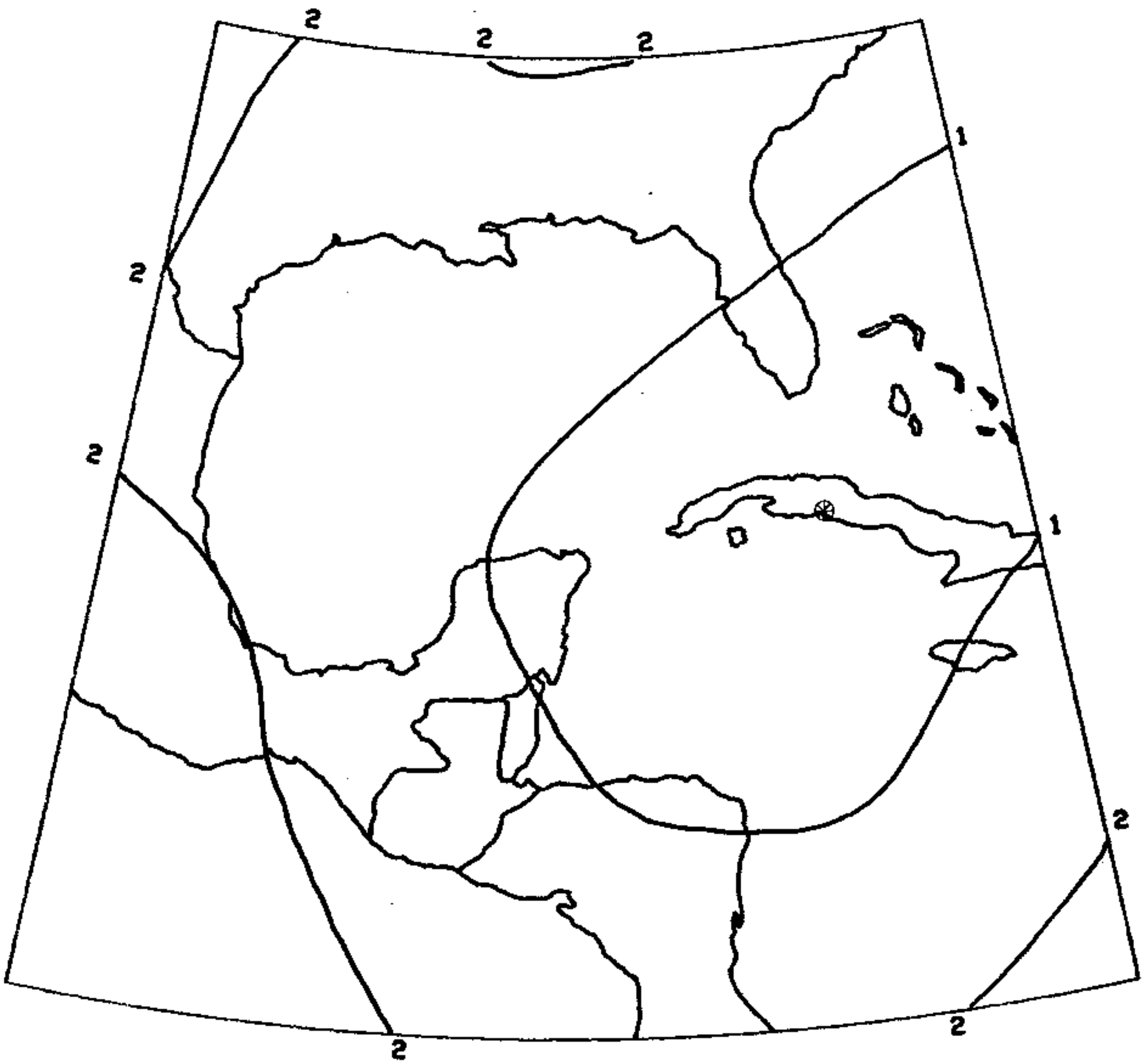

Exhibit 5. **Earliest arrival, in days, of air from Cienfuegos, Cuba based on a year of trajectory calculations (1984).**

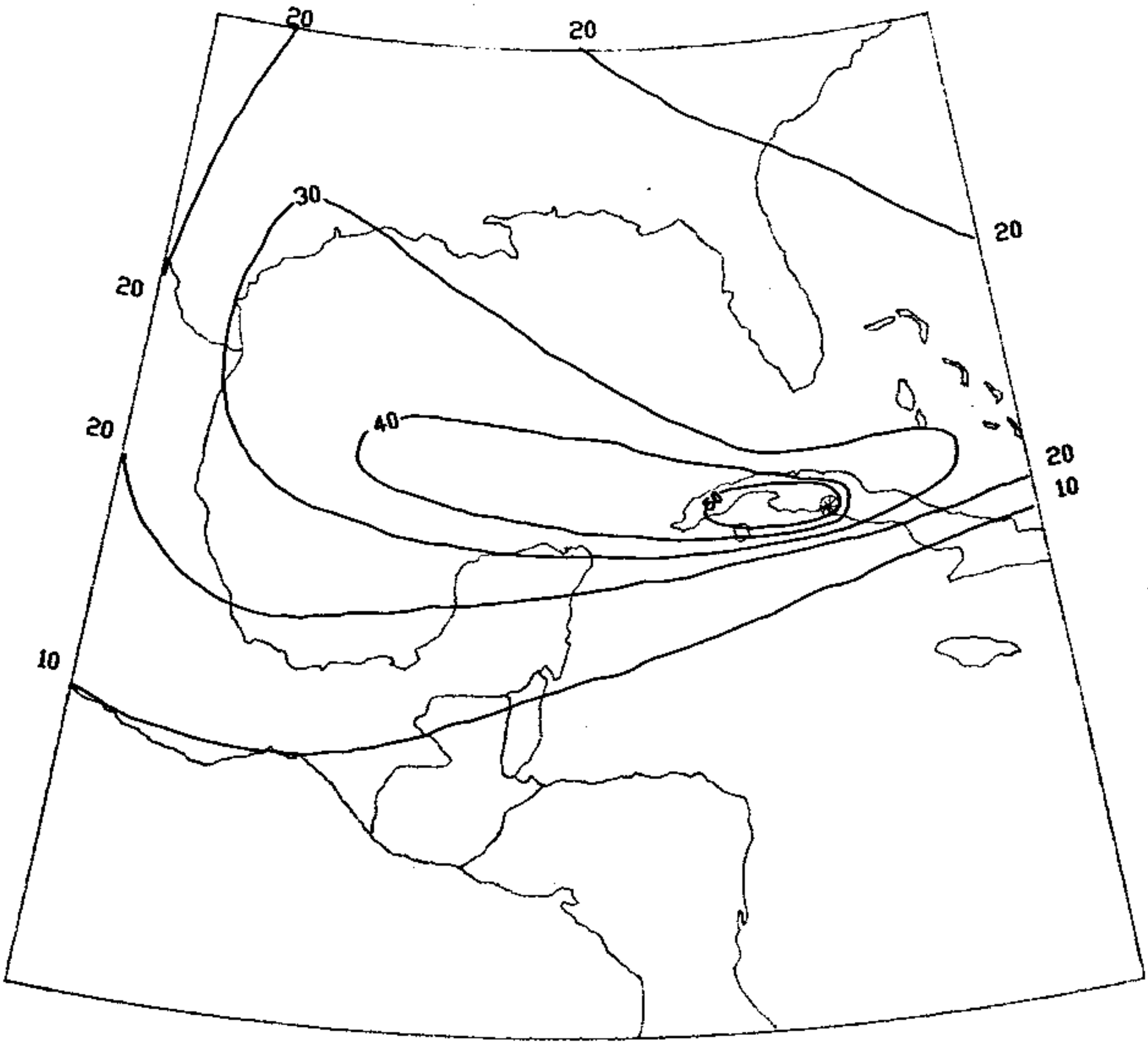

Exhibit 6. Percentage of time that air originating at Cienfuegos, Cuba would override an area during the period April 1 through June 30, 1984.

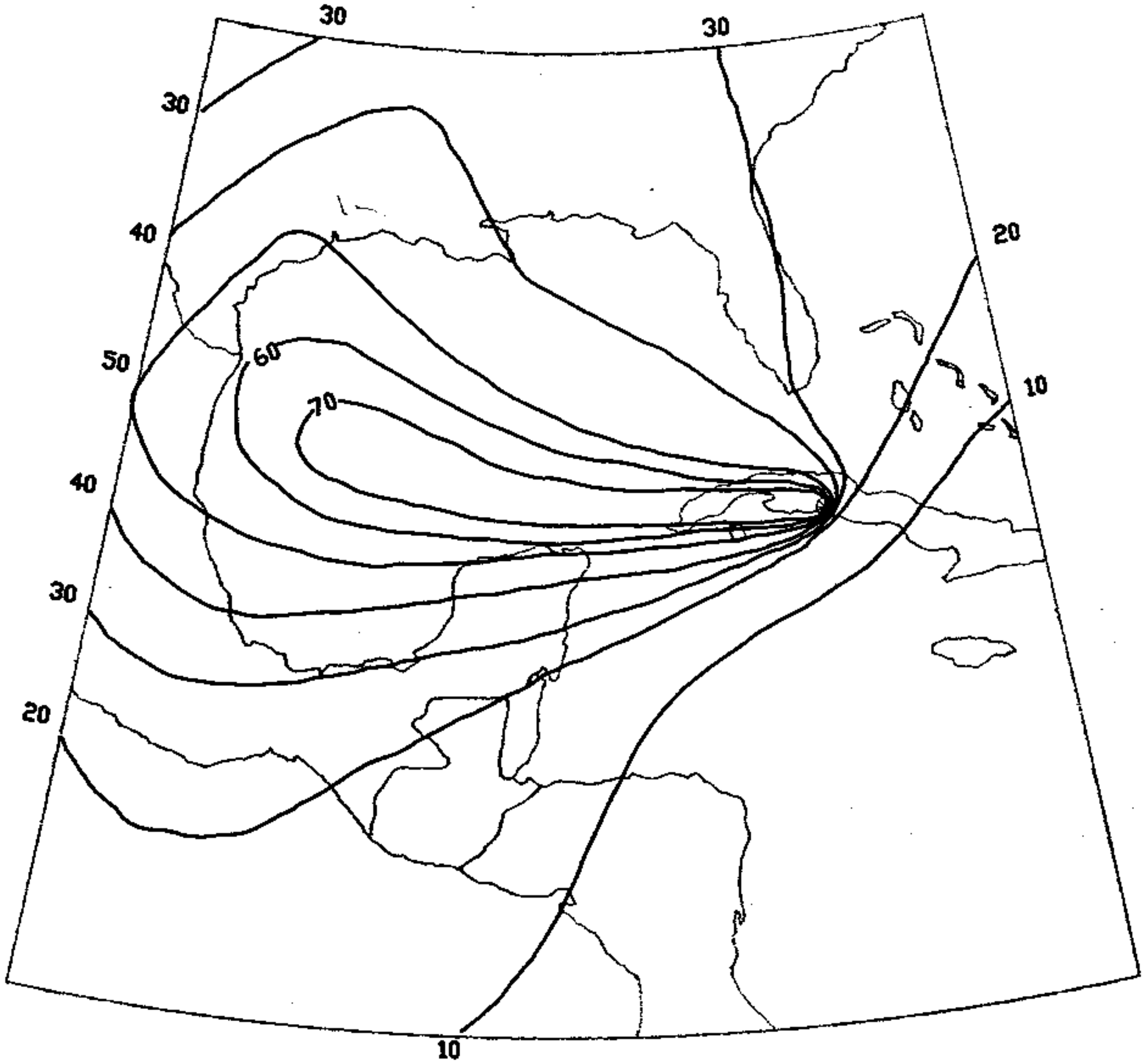

Exhibit 7. **Percentage of time that air originating at Cienfuegos, Cuba would override an area during the period July 1 through September 30, 1984.**

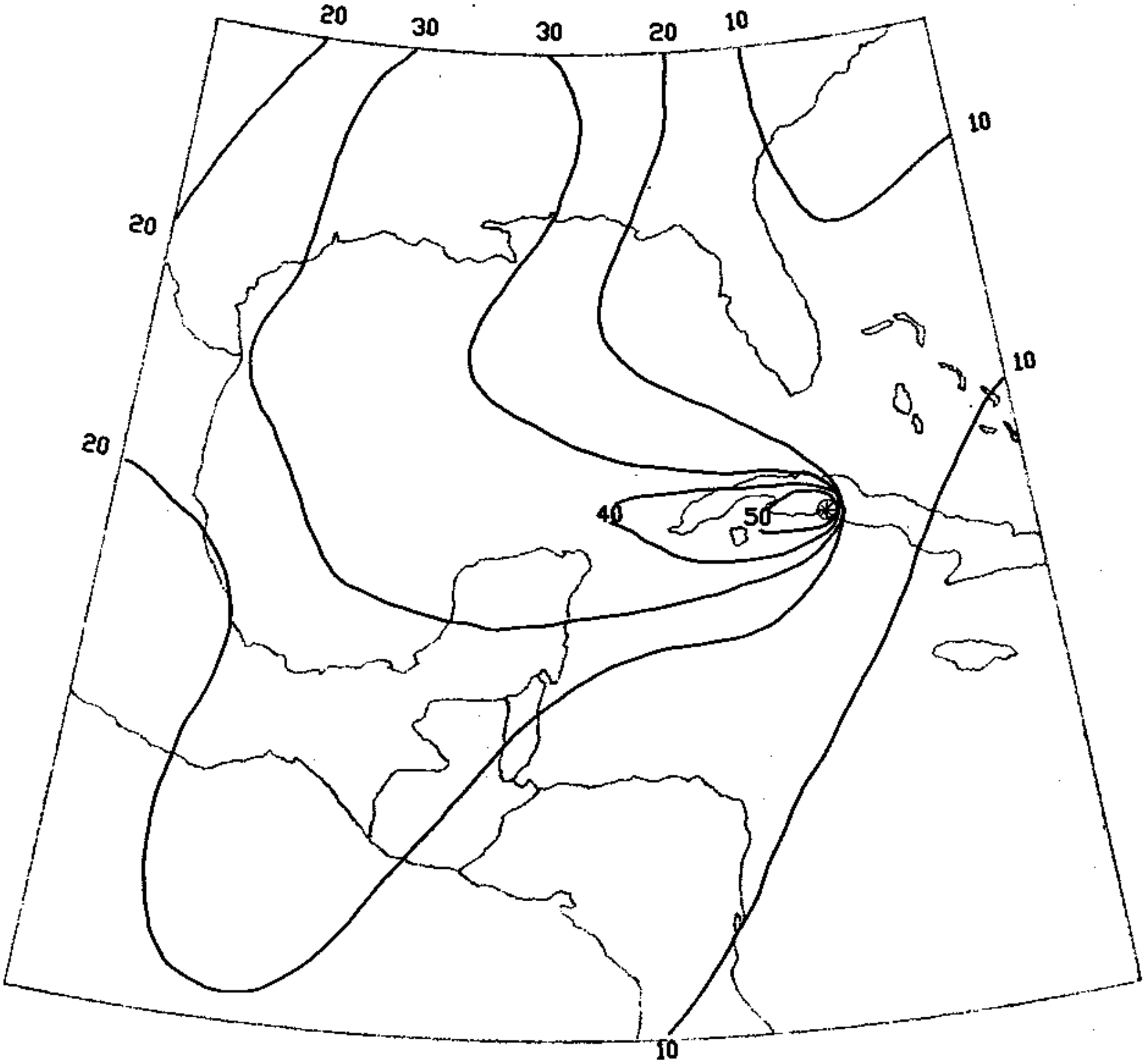

Exhibit 8. Percentage of time that air originating at Cienfuegos, Cuba would override an area during the period October 1 through December 31, 1984.

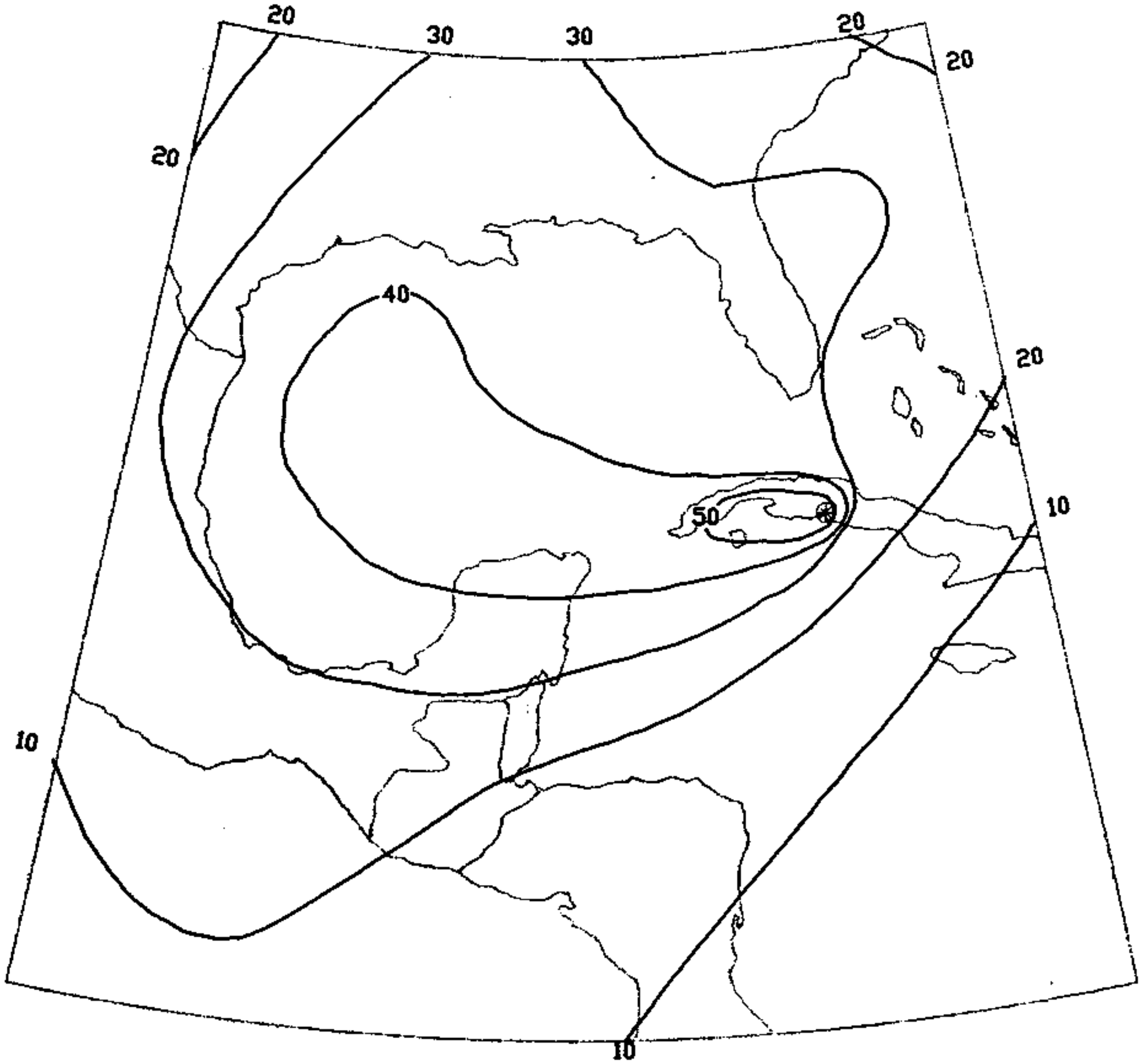

Exhibit 9. Percentage of time that air originating at Cienfuegos, Cuba would override an area during the course of the year 1985.

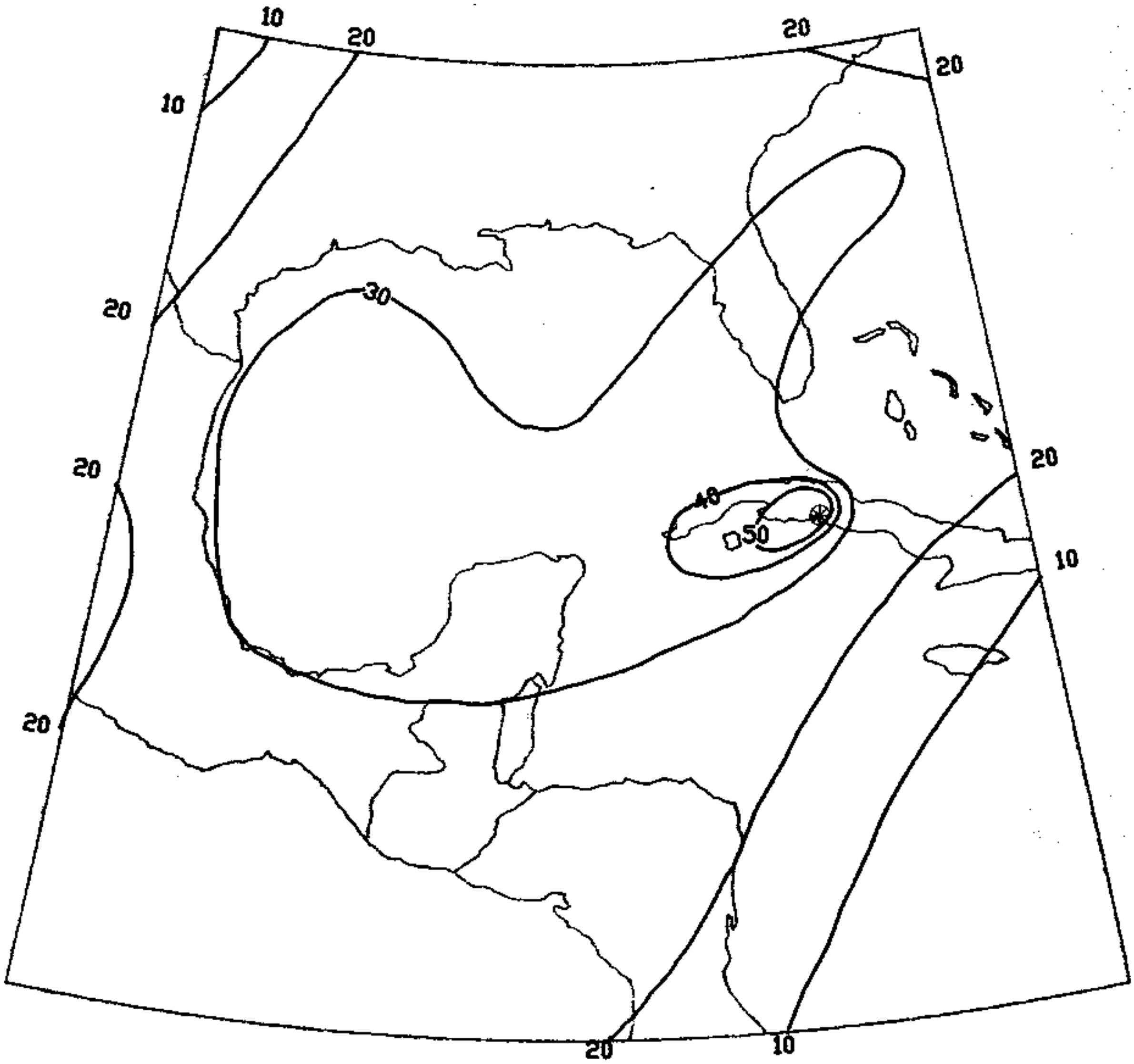

Exhibit 10. Percentage of time that air originating at Cienfuegos, Cuba would override an area during the period January 1 through March 31, 1985

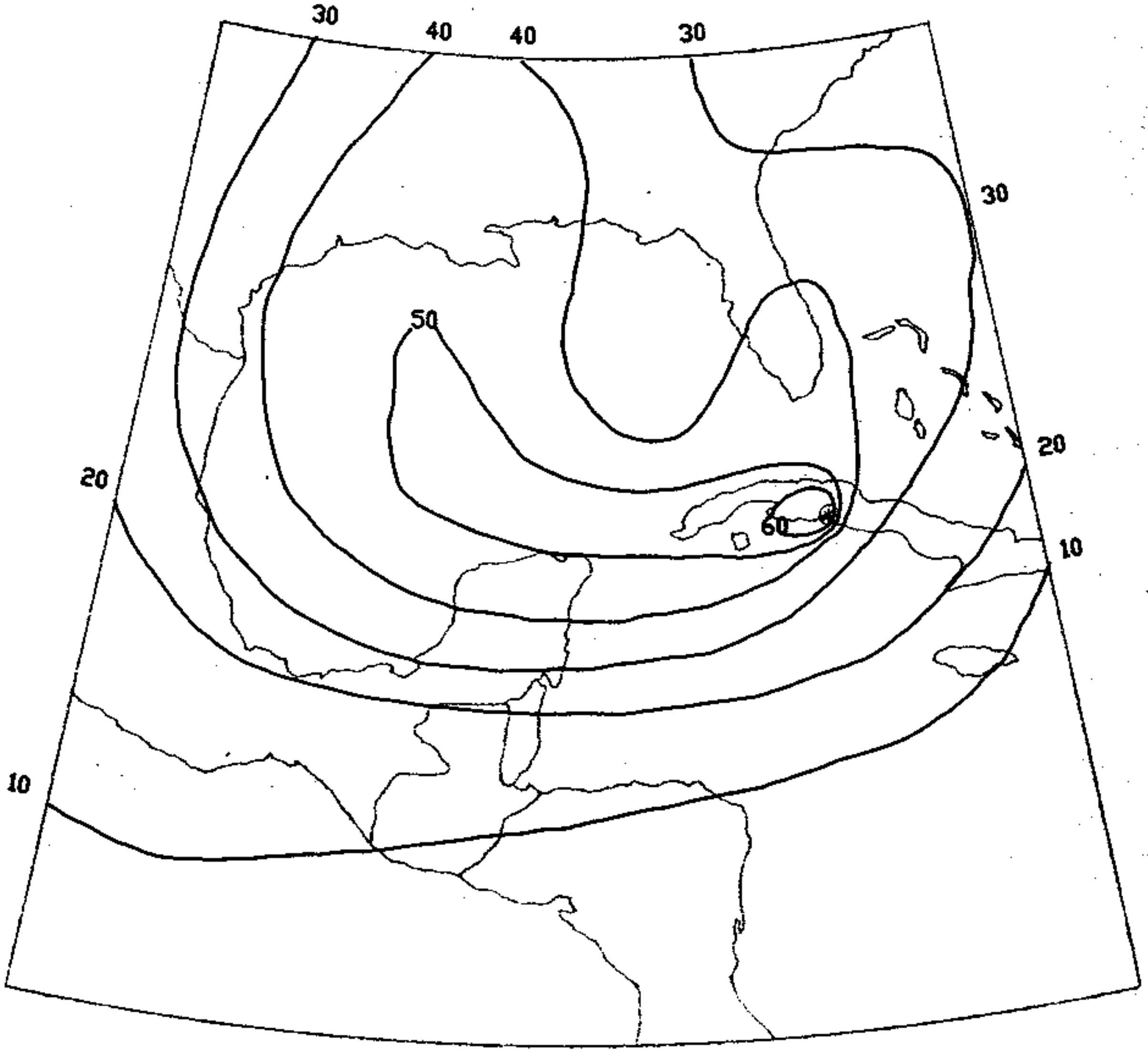

Exhibit 11. **Percentage of time that air originating at Cienfuegos, Cuba would override an area during the period April 1 through June 30, 1985.**

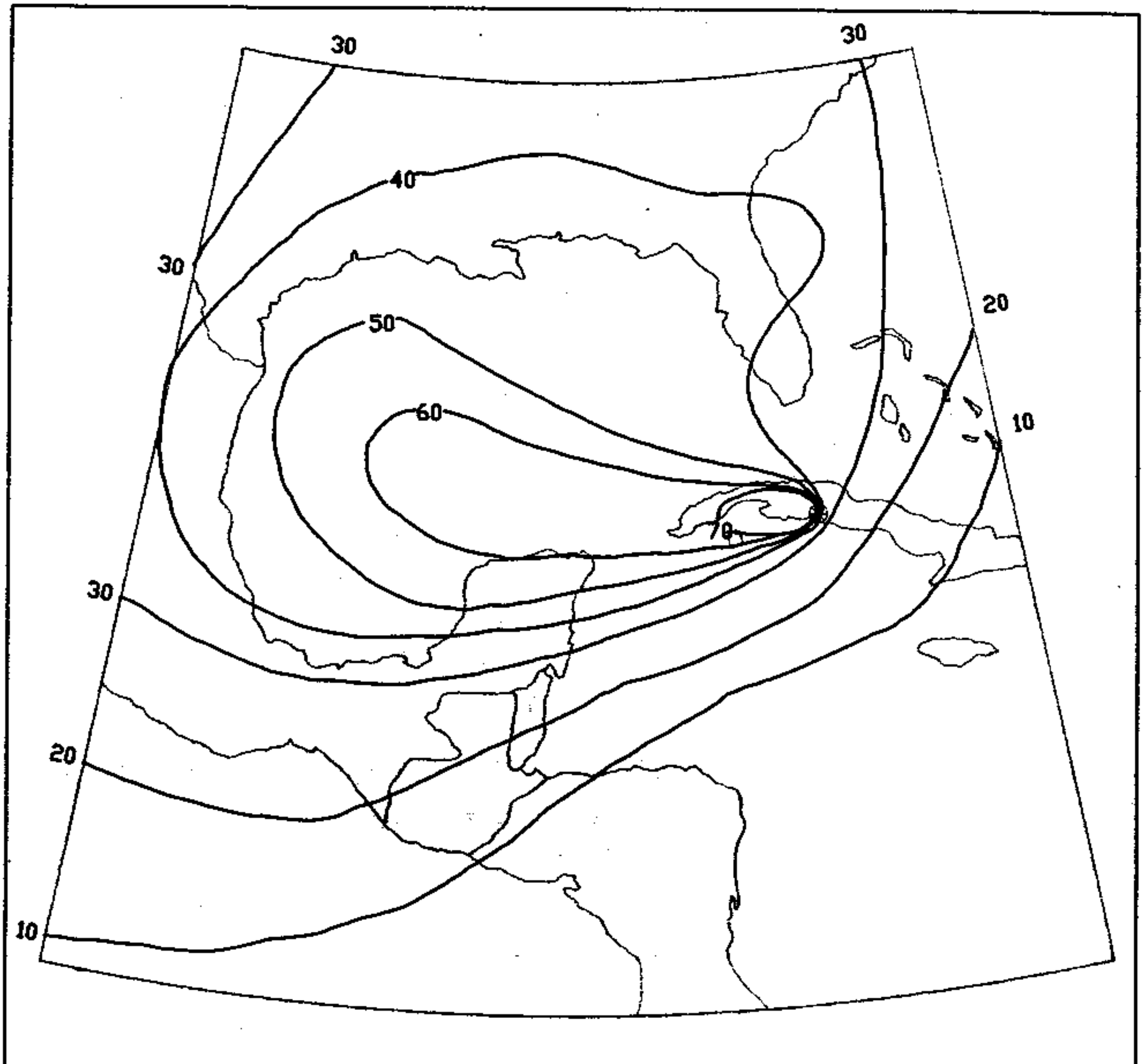

Exhibit 12. Percentage of time that air originating at Cienfuegos, Cuba would override an area during the period July 1 through September 30, 1985.

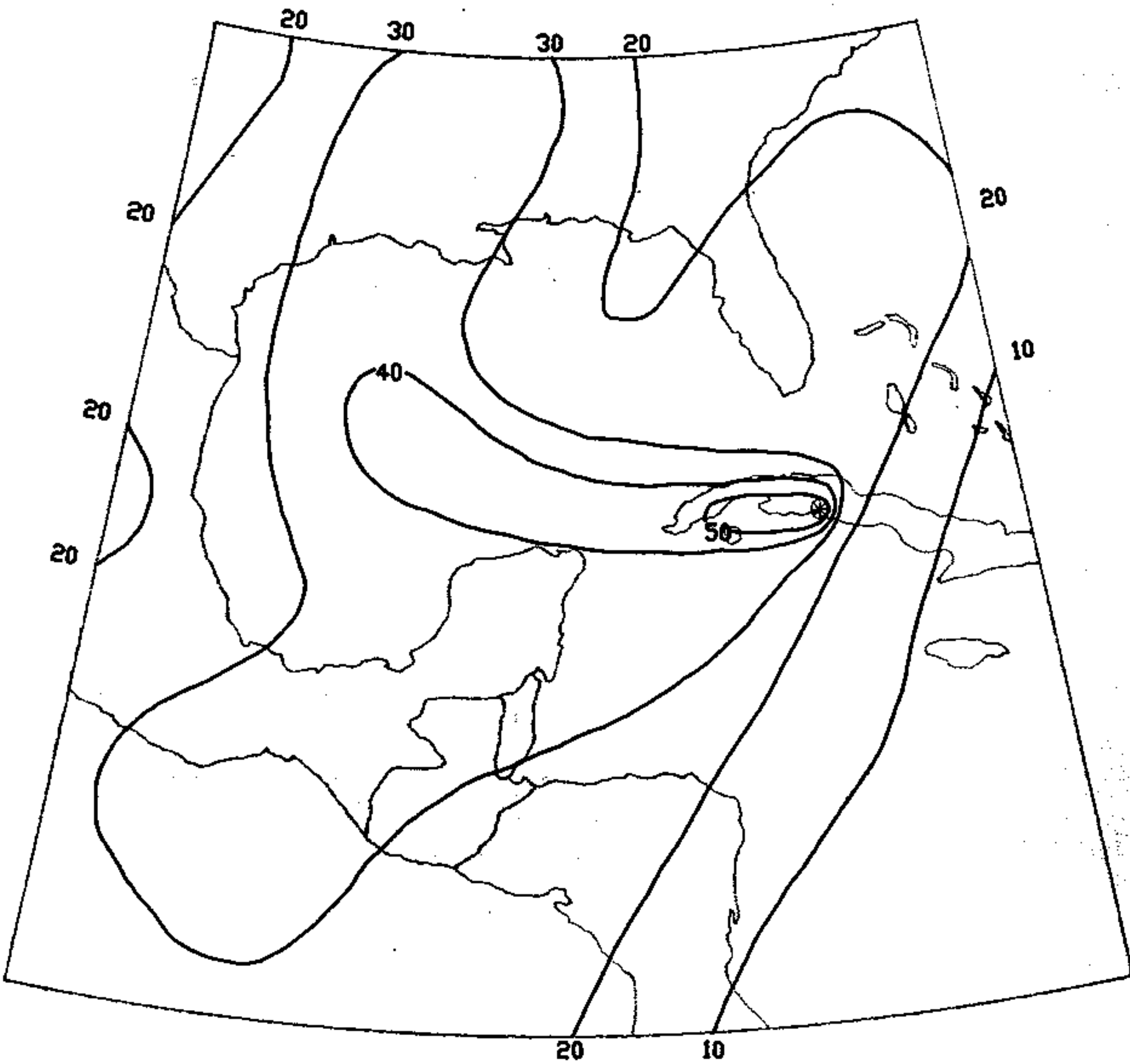

Exhibit 13. Percentage of time that air originating at Cienfuegos, Cuba would override an area during the period October 1 through December 31, 1985.